Data recovery from historic shipwrecks: corrosion layers reveal the past, present & future

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BAT 916

cracked coin

Batavia corroded from 1629-1976
Bat 916 corrosion products

Corrosion products trapped inside the hollow coin provide the clues
• hollow coin
• minted in Gelderland 1568
• why?
Dirk Hartog 1616

de Vlamingh 1697

1445 gram, 370 mm diameter, 5.55 mm thick

very fragile & precious
Mobilisation of surface from crystallisation of liquid matrix

Letters are made with a punch
Radiating stress lines from Fe & Cu nail holes

60 kV 2 minutes
reverse profile
plate very fragile
corroded pewter

Perspex mount
foam isolation under
spring steel holders
Phase diagram for Sn & Pb alloys

Line analysis 79% Sn, 14% Pb, 4.7% Cu, 3.2% Bi, 0.83% Zn,
Recrystallised structure

69% Pb 21% Sn
ICP-MS analysis of the de Vlamingh plate

Cornwall: stannite $\text{Cu}_2\text{FeSnS}_4$

Derbyshire: gladite $\text{Cu}_2\text{Pb}_2\text{Bi}_{10}\text{S}_{18}$

- Sn: 79%
- Pb: 14%
- Cu: 4%
- Bi: 3%
- Zn: 0%

79% Sn, 14% Pb, 4% Cu, 3% Bi
HMS *Sirius* (1790) sank at Norfolk Island

hundreds of ballast pigs,
a few anchors
a couple of cannon
in-situ electrolysis removes chlorides stabilizes degraded mushy matrices

3 years of treatment in the surf extracted

78 kg Cl⁻
Coins have dates & assayers names which really helps the archaeologists.

- Anaerobic i.e. buried $\rightarrow \text{Ag}_2\text{S}$
- Aerobic or exposed $\rightarrow \text{AgCl}$
Cyclonic action at the Ningaloo reef

bands of sulphide & chloride
MacLeod & North: $E_{\text{corr}}$ and pH measurements on engine in 1983
Corrosion rings on *Xantho* engine

• Site is buried and exposed every 7 years
Good casting

recovery angle

the stranding angle

Good casting
Body checks on iron wrecks

Rate of corrosion is directly linked to pH

\[ \text{Fe(H}_2\text{O)}_6^{2+} \rightarrow \text{Fe(H}_2\text{O)}_5(\text{OH})^+ + \text{H}^+ \]
Graphitisation of cast iron

\[ \log d_g = 0.758 - 0.26 \text{ pH} \]

Corrosion rate mm/year
Corrosion on the Fujikawa Maru

- Forward gun 11.6 mm: 0.199/year
- Bow bollards 6.5 & 6.6 mm: 0.112 & 0.113/year
- Windlass 8.4 mm: 0.144/year
HMS Pandora (1791) watch before & after conservation